Development And Demonstration Of Nitrogen Best Management Practices For Sweet Corn In The Low Desert

FREP Contract # 97-0365 M98-05

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Introduction

Large amounts of fertilizer are typically used to produce high quality sweet corn. Rates of N applied to sweet corn in the desert often exceed 300 kg N/ha. This project seeks to identify and demonstrate N best management practices (BMPs) for sweet corn. In 2001-2002, we initiated N studies aimed at evaluating several diagnostic tools for efficient N management of sweet corn (*Zea mays*). Diagnostic tools evaluated included the traditional dry stalk nitrate-N test, the traditional soil nitrate-N test, and a quick soil test.

Studies conducted in the spring and fall of 2001-2002 were designed to evaluate the response of sweet corn to side dress N fertilizer applications and test the effectiveness of various diagnostic plant and soil tests as predictive tools. We selected sites with two different grower cooperators in the Coachella Valley. Typically sweet corn planted in the spring is following lettuce, broccoli or cauliflower. Sweet corn planted in the fall generally follows leaching of the fields with large amounts of irrigation water.

Project Objectives

1. Evaluate and demonstrate efficient nitrogen (N) fertilizer practices for sweet corn, including the use of rate, timing, placement of N fertilizers to develop Best Management Practices.
2. Develop and demonstrate diagnostic tools for N management of desert-grown sweet corn.
3. Evaluate the effects of N management on post-harvest quality of sweet corn.

Project Description

Four field experiments were conducted in 2001-2002 to evaluate, and demonstrate to growers several diagnostic tools. The experiments in order were designated as 47H, 47I, 47J, 47K and were conducted in grower fields. We selected sites in the Thermal and Indio areas of the Coachella Valley.

The crop, planting date, final harvest and location of each experiment are shown below.

Experiment	Crop	Planting Date	Harvest Date	Location
47H	Sweet corn	02-16-01	05-22-01	Thermal
47I	Sweet corn	02-19-01	05-23-01	Indio
47J	Sweet corn	08-18-01	Lost	Thermal
47K	Sweet corn	02-18-02	05-20-02	Indio

In all experiments sweet corn was seeded to a stand in single row beds. Individual plots in all sites were approximately 65m^2 (15.24 by 4.26 m) in size. All pest control and cultural operations were performed using standard practices. All stands were established using sprinkler irrigation. After stand establishment, water was applied by furrow irrigation.

Field experiments 47H-47K consisted of 4 treatments (two N fertilizer applications after planting) in a 2^2 factorial design. Rates of N used in each side dress application were those actually used by cooperating growers and ranged from 30 gallons per acre (gpa) to 50 gpa of UN32 (approximately 70 to 118 kg N/ha).

Results

Studies conducted in 2001-2002 were designed to evaluate the response of sweet corn to sidedress N fertilizer applications and test the effectiveness of various diagnostic plant tests as predictive tools. We had no previous knowledge of the fields and we assumed that we would have N responsive sites. Unfortunately, most of the fields had high residual N values and positive responses to N fertilizer were minimal. Those results are still being analyzed and will be reported in the near future. This report will cover the

results of the post harvest studies.

Experiment 47H

The sweet corn from experiment 47H was harvested at near optimum maturity (Table 1). Tip fill did vary among treatments, but ear fill did not. After a total of 20 days at 0°C, overall visual quality of corn in husks was similar among treatments, although ear quality of treatment 4 was significantly less. Visual quality of silks and decay on silks were not different among ears from different N fertilization treatments (Table 1). Husk color was perceived as brighter green in treatments #2 and #4 (Table 2), and this corresponded to higher hue color values after 8 and 20 days at 0°C (32°F). Chroma and hue values decreased between 8 and 20 days of storage. There were small differences in kernel color at 8 days (Table 2).

Sweet corn kernel composition was significantly affected by N fertilization treatment. Higher soluble solids concentrations were obtained with no sidedress N (Trt #1) or 2nd sidedress N (Trt #3) (Table 3). Kernels from these same field treatments also contained higher sugar concentrations and had higher % dry weights than kernels from trt #2 and #4. With an additional 12 days at 0°C, soluble solids decreased an average of 12% and sugar concentrations decreased an average of 9%. The pericarp of the kernels, as % dry weight, did not differ among field treatments, although toughness of the pericarp was highest in treatments #1 and #2 and least in treatments #3 and #4. Sugars were also determined by HPLC (Table 4). Again, treatments #1 and #3 had the highest sugar concentrations. The proportions of sucrose, glucose and fructose were affected slightly by the N field treatments. Sucrose averaged 90-95% of total sugar concentrations, glucose averaged 4% and fructose averaged 3%. Treatment #2 (1st sidedress N) resulted in the lowest % of glucose and fructose and correspondingly the highest % of sucrose (Table 4). Sugars concentrations were highly correlated with soluble solids concentrations (Figure 1) and less highly correlated with % dry weight (Figure 2).

Preliminary sensory testing indicated that kernels from treatments #1 and #4 had stronger aroma and kernels from #2 has the best aroma, i.e., most typical of sweet corn. Flavor was similar among treatments #1, #2 and #3, and flavor of kernels from #4 was considered stronger (perhaps kernels more mature?). Kernels from all treatments were perceived as sweet, but kernels from #1 and #2 were perceived as sweeter than others. Texture and color were similar in kernels from all treatments.

Table 1. Visual quality of sweet corn in relation to 4 nitrogen fertilization treatments (2001, Exp. 47H). Corn was stored 8 days at 0°C (32°F) before evaluation of maturity, tip and earfill, and 20 days at 0°C for other evaluations. Data based on 3 reps of 4 ears each.

Nitrogen Fertilization Treatment	Maturity [1]	Tip Fill[2]	Ear Fill[2]	Visual[3] Quality Husk	Visual[3] Quality Ear	Visual[3] Quality Silk	Decay[4] Silk
1. No sidedress	2.0	2.1	3.0	6.9	7.2	4.0	3.9
2. First sidedress	2.0	2.2	3.0	7.1	7.2	3.2	3.7
3. Second sidedress	2.0	2.1	2.9	7.0	7.4	2.8	3.9

4. First & Second sidedress	2.0	2.5	3.0	6.8	6.8	2.8	3.8
Average	*2.0*	*2.2*	*3.0*	*7.0*	*7.2*	*3.2*	*3.8*
LSD.05	ns	0.3	ns	0.2	0.5	ns	ns

[1] Maturity: 1=immature, kernels small, 2=optimum maturity, 3=overmature, kernel sap milky; evaluation of 8 ears per rep, 3 reps.
[2] Tip fill and ear fill (kernel fill): 1=kernels not fill end or length of ear, 2=moderately well filled, 3=well filled; evaluation of 8 ears rep, 3 reps.
[3] Visual quality of intact ear in husk, silks and husked ear was scored on a scale of 9 to 1, where 9=excellent, 7=good, 5=fair, 3=poor and 1=unuseable; a score of 6 is the limit of salability.
[4] Decay on silks was scored on a 1 to 5 scale, 1=none, 2=slight, 3=moderate, 4=moderately severe, 5=severe.

Table 2. Color values of sweet corn in relation to 4 nitrogen fertilization treatments (2001, Exp. 47H). Corn was stored 8 and 20 days at 0°C (32°F) before evaluation.

Nitrogen Fertilization Treatment	Days at 0°C (32°F)	Husk				Kernel		
		Color[1] Score	L*[2]	Chroma[2]	Hue[2]	L*[2]	Chroma[2]	Hue[2]
1. No sidedress	8	3.5	69.0	33.6	111.3	71.4	13.9	98.9
2. First sidedress	8	4.1	67.1	33.0	113.1	71.7	14.5	98.7
3. Second sidedress	8	3.8	67.4	33.0	111.9	70.6	13.7	99.0
4. First & Second sidedress	8	4.4	64.4	32.1	114.0	72.4	15.5	98.3
Average		*4.0*	*67.0*	*32.9*	*112.6*	*71.5*	*14.4*	*98.7*
1. No sidedress	20	--	68.8	32.4	109.6	--	--	--
2. First sidedress	20	--	62.4	30.0	113.7	--	--	--
3. Second sidedress	20	--	67.9	33.2	109.5	--	--	--
4. First & Second sidedress	20	--	61.5	30.3	114.9	--	--	--
Average			*65.1*	*31.5*	*111.9*			
LSD.05		0.4	2.0	1.2	1.2	ns	0.9	0.6

[1] Husk color evaluated on a 5 to 1 scale, where 1=light green, 3=bright green, 5=dark green.
[2] L* represents lightness or darkness (0=black, 100=white) and chroma represents the intensity of the green or yellow color, the higher the value the brighter the color appears; hue represents true color. Chroma and hue values are calculated as $(a^{*2} + b^{*2})^{1/2}$ and $\tan^{-1}$ (b*/a*).

Table 3. Composition and color values of sweet corn in relation to 4 nitrogen fertilization treatments (2001, Exp. 47H). Corn was stored 8 days at 0°C (32°F) before evaluation.

Nitrogen Fertilization Treatment	Days at 0°C (32°F)	Soluble Solids,[1] %	% Dry weight	Sugars[2] mg/g DW	Pericarp[3] Toughness, Newtons	Pericarp, % of Dry Weight
1. No sidedress	8	18.0	27.0	416	5.27	2.9
2. First sidedress	8	16.8	26.0	384	5.32	2.8
3. Second sidedress	8	17.9	26.5	423	4.99	2.7

4. First & Second sidedress	8	15.5	24.8	382	5.18	2.8
Average		*17.1*	*26.1*	*401*	*5.22*	*2.8*
1. No sidedress	20	16.2	25.5	380	5.24	--
2. First sidedress	20	14.4	24.0	358	5.27	--
3. Second sidedress	20	16.3	25.9	414	5.40	--
4. First & Second sidedress	20	13.7	24.2	316	5.34	--
Average		*15.1*	*24.9*	*367*	*5.28*	
LSD.05		0.5	0.8	20	0.14	ns

[1] Soluble solids determined by refractometer.
[2] Sugars were determined on ethanol extracts by colorimetry.
[3] Pericarp toughness determined on 30 kernels per rep x 3 reps by measuring the resistance to penetration of a 2 mm flat cylinder probe on TA-XT texture analyzer, 2 mm deep.

Table 4. HPLC analysis of sugars in sweet corn in relation to 4 nitrogen fertilization treatments (2001, Exp. 47H). Corn was stored 8 days at 0°C (32°F) before analysis.

Nitrogen Fertilization Treatment	Sucrose, mg/g DW	%	Glucose, mg/g DW	%	Fructose, mg/g DW	%	Total Sugars, mg/g DW
1. No sidedress	391	93	15	4	15	4	421
2. First sidedress	365	95	8	2	9	2	383
3. Second sidedress	390	92	22	5	13	3	426
4. First & Second sidedress	308	90	20	6	14	4	342
Average	*364*	*92*	*16*	*4*	*13*	*3*	*393*
LSD.05	24		6		3		25

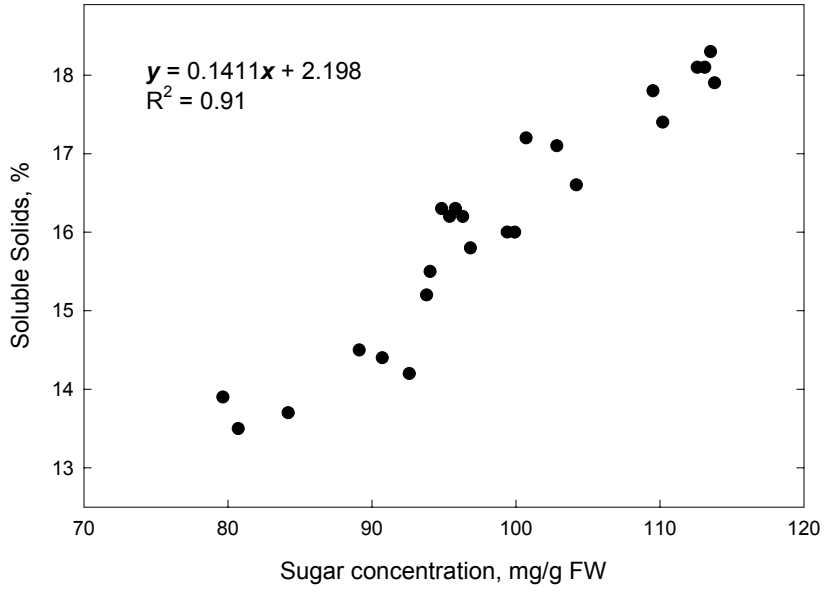

Figure 1. Relationships between soluble solids and sugar concentrations (colorimetric) in kernels of sweet corn stored 8 and 20 days at 0°C (32°F) from Exp. 47H, May 2001.

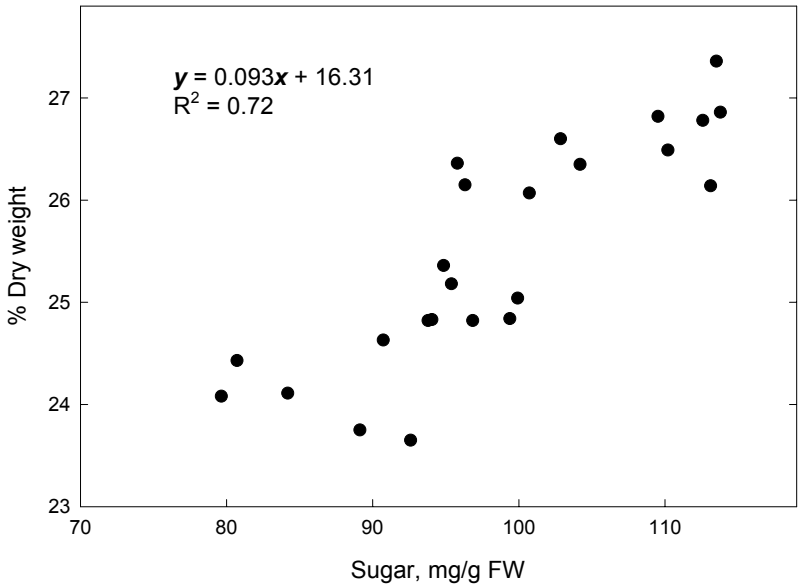

Figure 2. Relationships between % dry weight and sugar concentrations (colorimetric) in kernels of sweet corn stored 8 and 20 days at 0°C (32°F) from Exp. 47H, May 2001.

Experiment 47I

There were no significant differences in maturity, tip fill, ear fill, or husk color of corn from the 4 field treatments (Table 5). Some of the kernels on the ears were observed to be dry and dehydrated, and this defect was scored. However, no differences in dehydrated kernels were found among field treatments (Table 5).

Husk and kernel chroma and hue color values were not different among field treatments (Table 6). However, soluble solids concentrations were significantly lower in kernels from treatments #3 an #4. The average soluble solids concentrations were 2-3% lower than values in corn from another experiment harvested at the same period (Exp. 47H). There were no significant differences in % dry weight (Table 6). There were also significant differences in pericarp toughness, with the toughest kernels being those from the 2nd sidedress treatment #3 (Table 6). Pericarp toughness was similar in kernels from the other 3 field treatments.

Preliminary sensory testing indicated that kernels from all treatments had typical, but not strong aromas. There were no discernible differences in aroma among the 4 field treatments. Kernels from #1 and #4 were perceived as being less sweet than kernels from treatments #2 and #3. Kernels from treatments #1 and #4 were perceived as being tougher than kernels from other treatments. Maturity may have affected the toughness evaluations since kernels from treatment #4 were smaller than kernels from #2 and #3. Color was similar among treatments except color of kernels from treatment #1 appeared to be slightly darker.

Table 5. Visual quality of sweet corn in relation to 4 nitrogen fertilization treatments (2001, Exp. 47I). Corn was stored 8 days at 0°C (32°F) before evaluation. Evaluations were based on 3 replications of 4 ears each from a composite field sample.

Nitrogen Fertilization Treatment	Maturity[1]	Tip Fill[2]	Ear Fill[2]	Husk [3] Color	Dry [4] Kernels
1. No sidedress	2.5	2.7	3.0	4.5	1.9
2. First sidedress only	2.5	2.8	3.0	4.6	1.9
3. Second sidedress only	2.5	2.8	3.0	4.7	1.8
4. First & Second sidedress	2.5	3.0	3.0	4.4	1.9
Average	2.5	2.8	3.0	4.6	1.9
LSD.05	ns	ns	ns	ns	ns

[1] Maturity: 1=immature, kernels small, 2=optimum maturity, 3=overmature, kernel sap milky; evaluation of 8 ears per rep, 3 reps.
[2] Tip fill and ear fill (kernel fill): 1=kernels not fill end or length of ear, 2=moderately well filled, 3=well filled; evaluation of 8 ears rep, 3 reps.
[3] Husk color evaluated on a 5 to 1 scale, where 1=light green, 3=bright green, 5=dark green.
[4] Dry kernels 1=none, 2=moderate, a few kernels affected, 3=severe, numerous kernels affected

Table 6. Composition and color values of sweet corn in relation to 4 nitrogen fertilization treatments (2001, Exp. 47I). Corn was stored 8 days at 0°C (32°F) before evaluation.

Nitrogen Fertilization Treatment	Soluble [1] Solids, %	% Dry weight	Pericarp [2] Toughness, Newtons	Husk[3] Color, Chroma	Husk[3] Color, Hue	Kernel[3] Color, Chroma	Kernel[3] Color, Hue
1. No sidedress	14.5	24.8	5.19	27.7	118.9	16.0	98.1
2. First sidedress	14.8	25.2	5.21	28.1	119.4	16.2	97.8
3. Second sidedress	13.2	24.6	5.34	26.3	119.8	16.2	97.7
4. First & Second sidedress	12.5	24.1	5.12	28.0	118.7	16.1	97.8
Average	13.8	24.7	5.22	27.5	119.2	16.1	97.9
LSD.05	0.7	ns	0.14	ns	ns	ns	ns

[1] Soluble solids determined by refractometer.
[2] Pericarp toughness determined on 30 kernels per rep x 3 reps by measuring the resistance to penetration of a 2 mm flat cylinder probe on TA-XT texture analyzer, 2 mm deep.
[3] Chroma represents the intensity of the green or yellow color, the higher the value the brighter the color appears; hue represents true color; values are calculated from a* and b* objective color values.

Experiment 47K

The sweet corn from this experiment was harvested at near optimum maturity (Table 7). Ears of treatment #4 were slightly but significantly more advanced in maturity than ears

from treatments #1, 2, and 3. Neither tip fill nor earfill varied among treatments. After a total of 6 days at 5°C (41°F) or 8 days from harvest, corn from all treatments was rated "good" and was above the limit of salability (Table 7). There were no significant differences in the overall visual quality of corn in husks or of the decay on silks among the 4 fertilization treatments (Table 7).

Husk color scores were higher on treatments #1 and #2 at harvest but there were no perceived color differences after storage (Table 8). Hue color values of the husks (overall indication of greenness) were also higher for these 2 treatments at harvest, but there were no differences among the fertilization treatments after storage (Table 8). There were some significant but minor differences in color values of the kernels at harvest and after storage (Table 8).

Sweet corn kernel composition was not affected by N fertilization treatment (Table 9). The % soluble solids averaged 16.5% at harvest and 13.7% after storage, indicating a 17% loss of soluble solids (mostly sugars) with 6 days at 5°C (41°F). The % dry weight of the kernels also decreased significantly with storage but was not different among the N fertilization treatments.

The pericarp toughness values or texture of kernels (Table 9) from Treatment #4 were the highest among the 4 N fertilization treatments, while values for Treatment #2 were the lowest (significant difference between these 2 treatments). Values increased about 2.5% with storage at 5°C (41°F) and after storage there were no significant differences among fertilization treatments (Table 9).

Table 7. Visual quality of sweet corn in relation to 4 nitrogen fertilization treatments (2002, Exp. 47K). Corn was stored for 0 or 6 days at 5°C (41°F) before evaluation (2 and 8 days from harvest date). Data based on 3 reps of 6 ears each.

Nitrogen Fertilization Treatment	Days stored	Maturity[1]	Tip Fill[2]	Ear Fill[2]	Visual[3] Quality Ear	Decay[4] Silk
1. No sidedress	0	2.03	2.7	3	--	--
2. First sidedress	0	2.03	2.8	3	--	--
2. First & Second sidedress	0	2.08	2.7	3	--	--
4. Second sidedress	0	2.19	2.7	3	--	--
Average		*2.08*	*2.7*	*3*		
1. No sidedress	6	2.14	2.6	3	7.1	1.5
2. First sidedress	6	2.17	2.6	3	7.2	1.3
3. First & Second sidedress	6	2.17	2.9	3	7.4	1.5
4. Second sidedress	6	2.17	2.7	3	7.6	1.4
Average		*2.16*	*2.7*	*3*	*7.3*	*1.4*
LSD.05		0.14	ns	ns	ns	ns

[1] Maturity: 1=immature, kernels small, 2=optimum maturity, 3=overmature, kernel sap milky.
[2] Tip fill and ear fill (kernel fill): 1=kernels not fill end or length of ear, 2=moderately well filled, 3=well filled;
[3] Visual quality of intact ear in husk, was scored on a scale of 9 to 1, where 9=excellent, 7=good, 5=fair, 3=poor and 1=unuseable; a score of 6 is the limit of salability.

[4] Decay on silks was scored on a 1 to 5 scale, 1=none, 2=slight, 3=moderate, 4=moderately severe, 5=severe.

Table 8. Color values and color score of sweet corn in relation to 4 nitrogen fertilization treatments (2002, Exp. 47K). Corn was stored 0 and 6 days at 5°C (41°F) before evaluation (corn was 2 and 8 days from harvest). Data are averages of 3 replicates of 6 ears each.

		Husk				Kernel		
Nitrogen Fertilization Treatment	Days at 5°C (41°F)	Color[1] Score	L*[2]	Chroma[2]	Hue[2]	L*[2]	Chroma[2]	Hue[2]
1. No sidedress	0	3.5	68.7	24.8	117.0	73.4	14.9	97.8
2. First sidedress	0	3.5	70.0	25.4	116.9	74.3	15.2	98.0
4. First & Second sidedress	0	3.4	70.8	24.6	115.6	74.8	15.5	97.8
4. Second sidedress	0	3.4	75.4	25.3	113.9	75.8	15.3	98.1
Average		*3.4*	*71.2*	*25.0*	*115.9*	*74.6*	*15.2*	*97.9*
1. No sidedress	6	3.0	72.9	25.8	112.4	75.1	15.4	97.3
2. First sidedress	6	3.1	70.2	24.1	113.3	74.6	15.8	97.1
5. First & Second sidedress	6	3.3	71.0	24.9	113.4	75.6	16.2	97.0
4. Second sidedress	6	3.1	71.1	25.1	113.1	75.1	15.4	97.3
Average		*3.1*	*71.3*	*25.0*	*113.0*	*75.1*	*15.7*	*97.1*
LSD.05		0.4	2.2	ns	1.5	ns	0.8	0.6

[1] Husk color evaluated on a 5 to scale, where 1=light green, 3=bright green, 5=dark green.
[2] L* represents lightness or darkness (0=black, 100=white) and chroma represents the intensity of the green or yellow color, the higher the value the brighter the color appears; hue represents true color. Chroma and hue values are calculated as $(a^{*2} + b^{*2})^{1/2}$ and $\tan^{-1}$ (b*/a*).

Table 9. Composition and texture of sweet corn in relation to 4 nitrogen fertilization treatments (2002, Exp. 47K). Corn was stored for 0 or 9 days at 5°C (41°F) before evaluation (2 and 8 days from harvest). Data for %SS and %DW are means of 3 replicates per treatment from a composite sample. Texture data are means of 3 replicates of 6 ears and 5 determinations each (90 determinations per treatment.

Nitrogen Fertilization Treatment	Days at 0°C (32°F)	Soluble Solids, %	Dry weight, %	Texture of kernels, Newtons
1. No sidedress	0	16.4	23.5	5.27
2. First sidedress	0	16.6	24.3	5.18
3. First & Second sidedress	0	16.4	23.5	5.37
4. Second sidedress	0	16.4	23.3	5.45
Average		*16.5*	*23.6*	*5.32*
1. No sidedress	6	13.3	23.3	5.48
2. First sidedress	6	15.0	23.6	5.34
3. First & Second sidedress	6	13.5	21.9	5.49
4. Second sidedress	6	13.2	23.4	5.41
Average		*13.7*	*23.1*	*5.43*
LSD.05		0.6	0.5	0.17